Iron-based Metal oxide nanostructures for gas sensor and magnetic applications.

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Submitted by

Mr. Paikrao Vishal Bhimrao

Under the guidance of

Dr. Ravi Sopan Kawale

Dnyanopasak Shikshan Mandals ACS College, Jintur

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Introduction

The surrounding environment and other relevant information are in different ways that need to identify by the human. To broaden the limits of our own perceptions, we have created a wide variety of sensors. Sensors can help us identify various forms of relevant information in the surrounding environment and convert this information into electrical signals or other required forms of information output through specific mechanisms to meet various needs in production and life. Gas sensors are one of the most commonly used types of sensors. The main function of gas sensors is to detect gases whose concentration is lower than the human olfactory limit (ppm level, ppb level or even ppt level) or gases that pose a threat to human health even at a lower concentration and such sensors are therefore widely used in various fields.

Among many gas sensing materials, Iron-based oxides could be greatly altered by catalyst structure engineering. Perovskite (ABO_3) oxides are an important class of functional materials, the structure of which can be significantly modulated by even slight substitution of A or B site cations [1, 2]. Iron-based oxides exhibit superior performance over other sensors due to their excellent physical and chemical properties and unique structure [3]. In some strict environmental tests, gas sensors are used to monitor the concentration of gases such as H_2S, NO_2, and volatile organic compounds (VOCs) to ensure that the immediate environment is suitable for human survival or work [4, 5]. Gas sensors have been used to monitor the concentration of flammable and explosive gases in factories. monitoring is to avoid people reacting too slowly when gas leaks, which can result in casualties. Especially in recent years, with the increasing use of natural gas and hydrogen, the use of such sensors has become more widespread. Another important application of gas sensors is breath analysis. Novel ethanol sensors can be used in the field of traffic safety, and among many gas sensing materials, metal oxide semiconductors (MOSs) exhibit superior performance over other sensors due to their excellent physical and chemical properties and unique structure [6-8]. These materials have a wide band gap, allowing them to have a full spectrum of electronic properties (insulating ⇌ semiconducting). The properties of MOSs are often greatly affected by the material size. In particular, at the nanoscale, a material will show unique properties due to the nano effect. For example, the electrical properties undergo very significant changes, creating a good gas sensing material. Commonly used MOS gas sensing materials are divided into n-type and p-type materials, including ZnO, SnO_2, MoO_3, NiO and Cu_2O. In addition, these MOSs have better stability and quick response in high-temperature or harsh environments.

Tailor-made binary or ternary oxide-bearing gas-sensing functionalities constitute a rich material playground for the realization of enhanced gas sensing in resistive-type gas sensors [9]. Among them, perovskite oxides remain prominent and exhibit a wide range of Physico-chemical properties, and tunable electronic conductivity compared to binary metal oxides such as SnO_2, ZnO, CuO, Co_3O_4, NiO, TiO_2, CeO_2, and WO_3. Perovskite oxides with the stoichiometry ABO_3 have a cubic structure, where the larger cation A at each corner of a unit cell and the smaller cation B at the body center sites are 12- and 6-fold coordinated with oxygen anions at the face center sites, respectively. The sizes of A and B are determined by the

tolerance factor, whose value equals unity for perfectly matched A–O and B–O-bond lengths. Typically, the A-site cation at the dodecahedral site donates

electrons to the [BO_6] octahedra, whereas the B-site cation alters the electronic structure, influencing the physical properties of the perovskite oxide. Owing to the presence of oxygen vacancies, the stoichiometry of oxygen in ABO_3 perovskites deviates from 3, forming $ABO_{3-\delta}$ perovskite oxides with oxygen non-stoichiometry (δ).

The ability to host cationic and oxygen vacancies renders ABO_3 perovskites with variable electrical and redox properties, and synergistic catalytic functions, which bring about a critical impact on the gas-sensing property. In addition, their mechanical and thermal stability make them suitable gas-sensing materials in a wide range of temperatures.

Literature review

Chuande Huang et. al. detected methane to syngas with highly selectivity and durability using iron based $La_{0.6}Sr_{0.4}Fe_{0.8}Al_{0.2}O_{3-\delta}$ oxygen carrier for syngas production via a solar-driven thermochemical process [10].

Chunwen Sun et. at. worked on perovskite-type oxides for random access memory, energy conservation, and storage. He reviews on structure, defect chemistry, and transport properties of perovskite oxide materials [11].

Peresi Majura Bulemo et. al. work on lanthanide or alkali earth metal for A site and transition metals for B site in perovskite-type oxide for resistive type gas sensor. He showed the sensing mechanism involved in utilization in gas sensing applications [9].

Wenbo Qin et. al. synthesized LaCoO3 perovskite nanoparticles by sol-gel synthesis and the modified surface of ZnO. The composite structure of LaCoO3/ZnO shows improved gas sensing selectivity and response recovery time [12].

Aim

In this work, we focus on developing gas sensors based on the nanostructure include nanoparticle, metal-oxides. synthesize metal oxide, composite-based nanoparticles. Synthesis methods by using different precursors with different treatment and reaction conditions. The main purpose behind this work is to enhance the response and recovery time for sensor materials to increase the sensitivity of sensing materials for commercialization. And also developing with high activity, and selectivity.

Objectives

The main objective of the work is to develop and synthesize novel materials for gas sensor applications to enhance the performance of the above-mentioned applications. Materials include metal-oxide and metal.

- Synthesis of metal-oxides, nanostructure for gas sensing application.
- Increase the sensitivity of the gas sensor.

- Obtain excellent material for good sensitivity and better gas sensors.
- Materials characterization and optimization.
- Write and publish research articles in several reputed journals.

Methodology

We have several chemical methods for the synthesis of metal oxides Ex., sol-gel and wet chemical synthesis etc.

[1] Sol-gel

This is a simple chemical method for the synthesis of materials, in which a precursor solution of chemical compounds in the proper solvents is mixed and stirred on a hotplate converted into powders.

[2] Wet chemical synthesis

Wet chemical synthesis, also called solution dispensation, signifies an available, multipurpose and commanding approach for manufacturing materials with outstanding controller of their structural, chemical and physical properties. This develops of dominant status when synthesizing functional nanomaterials, which need exact switch and tunability of their properties, with size, shape, composition, surface chemistry, and crystal location, in order to achieve the desired presentations. Extraordinary progressions in the wet chemical synthesis of nanomaterials have been attained in new periods.

Characterization

After the synthesis of metal oxides and sulfides nanomaterials characterize the materials with different characterization techniques. We use XRD SEM, TEM, BET, FTIR, VSM etc.

[1] X-ray diffraction analysis (XRD) is used to analyze the phase formation of metal-oxides.

[2] The morphology, particle size and shape are revealed through field emission scanning microscopy (SEM)

[3] TEM is a powerful tool to study the properties of materials on the atomic scale, such as metals, and nanoparticles.

[4] FTIR provides information on the basis of chemical composition and physical state of the whole sample.

[5] BET (Brunauer, Emmett and Teller) the specific surface area of a sample is measured – including the pore size distribution.

[6] VSM (Vibrating sample magnetometry) is used to analyse the magnetic properties of the material.

Measurements

To check the performance of the nanomaterials for gas sensor measurements of materials.

- In the gas sensor study selectivity of gas for material shows good response we find and then response and recovery time for material analysis. And then the concentration of the gas change to study the performance.

Proposed work plan

- Literature survey
- Selection of materials
- Synthesis of metal-oxides
- Characterization
- Collecting data and optimizing
- Writing paper
- Publishing in reputed journals

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Research scholar Ph.D. supervisor

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